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ANALYSIS OF INPUT PROCESS PARAMETER OF SPOT WELDING WITH OUTPUT IN LOW CARBON STEEL FOR MANUFACTURING OF AUTOMOTIVE COMPONENTS

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ABSTRACT

Low carbon steel is most consumable material for manufacturing body frames and internal components of Light Utility Vehicles in Automobile industries. Resistance spot welding is one of the processes to join the parts in auto industries. The focus of this paper to find out qualified input process parameters like Welding current, Cycle time(Hold Cycle, Squeeze Cycle& Weld Cycle) with responses like Nugget diameter , Strength etc. The main part behind the research work is **Assembled Fuel Tank.** The basic material for manufacturing of tank is EDD (Extra Deep Draw) graded cold rolled material of 1.2 mm thick as per **Indian Standard-513.** The trials conducted for experiment on resistance spot welding machine made from **Nash Robotics & Automation, Nasik.** Design of Experiments performed with central composite design based on Response Surface methodology(RSM).

KEYWORDS: Low Carbon Steel, Welding Current, Strength, Design of Experiment

INTRODUCTION

The main difference between low carbon steel and alloyed steel to choose base material for joining through resistance spot welding is that, in low carbon steel resistance is lower which mediate amount of current to weld. The time and heat (current) distribution is simple which does not produce any metallurgical changes in base material. The chances of weld embitterment are less in low carbon steel. In resistance spot welding metal parts which are to be joined were heated to plastic state over its limited area by their resistance to flow of electric current with particular time cycle called as weld cycle. This process mostly adapted for light gauge material which can be lapped.

The amount of heat generated during welding process expressed by following way-

$$H=I^2RT$$

(H=Heat generated, I=Amount of current, R=Resistance of base material, T=Cycle time)

Before going to weld two lapped material pressed by electrode for particular period of time called as **Squeeze cycle**. Then Current is allowed to pass for particular cycle time called as **Weld cycle**. After cut –off the current supply, material is hold between two electrodes for achieving nugget between joints for particular period of time called as **Hold cycle.** Hence all the above cycle time and welding current are selected as input process parameters against out parameters are as Nugget diameter, Strength of weld. In resistance spot welding heat generated at interface surface of base material, where weld formation to be start.

LITERATURE REVIEW

Indian Standard[1] gives chemical composition of EDD(Extra Deep Draw) graded cold rolled low carbon steel with maximum value of allowable strength. M. Pournavari investigated[2] the effect of process variable like pressure,

current, welding time on low carbon steel with their failure mode and peak load to describe spot weld performance. Marashi & Pournavari studied the failure mechanism of spot welded specimen with microstructure details of heat affected zones of welded section[3]. Yun.J.Chaoo have studied [4] the ultimate strength and failure mechanism under combined Tensile/Shear loads. S.P.Tewari and Nitin Rathod investigated the impact of input process parameters like current, welding time of resistance spot welding with responses like nugget diameter and tensile strength on Low Carbon and HSLA Steel[5].

EXPERIMENTS

The main objective of this paper to implement process parameters of resistance spot weld for connecter bracket which is to be weld on top shell of fuel tank as shown in figure below. Thickness of top shell is 1.2 mm & connecter bracket is of 0.8 mm[1].

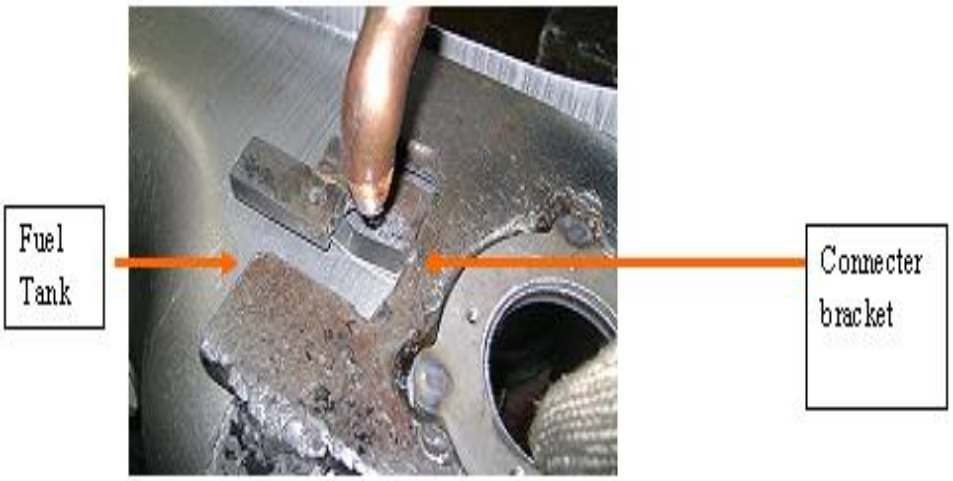

Figure 1: Connecter Bracket Spot Welding

TEST CONDITION AND MEASUREMENTS

Table 1: Chemical Composition of Cold Rolled Low Carbon Steel

Component	C	Mn	P	S
Required	0.08 Max	0.4 Max	0.4 Max	0.03Max
Observed	0.05	0.227	0.015	0.013

Welding is carried out with Resistance spot welding machine with, 120 KVA Supply, 415 Volt, Frequency -50 Hz with water-cooled conical copper electrodes, labeled as SP01. The chemical composition of cold rolled EDD graded steel as per table number 1. Specimens are prepared of size 1.2X0.8X150 mm and trial taken by spot welding process with above-mentioned parameters. Later on same specimens are tested for tensile strength on UTM machine. Hydraulic nature UTM machine made from **FAI Ichalkaranji** Maharashtra. Machine have capacity of about breaking load up to 4Tonnes with 5Kg Least count, which simultaneously gives the reading of nugget diameter & breaking load. The range of tensile strength decided as per by standard **IS 513**[1].

EXPERIMENTAL DESIGN

To achieve the above-mentioned aim, experiment planned carefully. Experiments were carried out with central composite design based on response surface methodology (RSM). Table number 2 shows the ranges and levels for independent input process parameter for resistance spot welding on specimens.

Table 2: Selected Range of in Process Parameter Values

Factor	Notation		-2 Lowest	-1 Low	0 Mid	1 High	2 Highest
Weld Time	Cycle	X1	10	11	12	13	14
Hold Time	Cycle	X2	10	15	20	25	30
Squeeze time	Cycle	X3	15	20	25	30	35
Current	Ampere	X4	11	11.1	11.2	11.3	11.5

Also Responses are selected and abbreviated with their ranges as per IS 513, as Nugget Diameter (Y1) up to 5 to 6 mm and Tensile strength (Y2) up to 270/350 N/mm^2 [1]. Total 25 numbers of experiments are done

Figure 2: Specimen for Nugget Test

Table 3: Design of Experiments Data with Responses

Sr No	Weld Cycle X1	Hold Cycle X2	Squeeze Cycle X3	Current X4	Nugget Dia in mm Y1	Breaking Load in N	Tensile Strength N/mm2
1	11	15	20	11.1	5.5	9516	275.5
2	13	15	20	11.1	5.1	9887	312.4
3	11	25	20	11.1	5.4	9693	276.3
4	13	25	20	11.1	5.2	9957.15	304.9
5	11	15	30	11.1	5.5	9614	278.3
6	13	15	30	11.1	5.1	10006.2	318.5
7	11	25	30	11.1	5.4	9731	281
8	13	25	30	11.1	5.2	10006.2	306.3
9	11	15	20	11.3	5.6	9609	273.35
10	13	15	20	11.3	5.4	9825.1	289.9
11	11	25	20	11.3	5.7	9712	271.28
12	13	25	20	11.3	5.3	9957	299.2
13	11	15	30	11.3	5.5	9516	275.5
14	13	15	30	11.3	5.2	9810	300.4
15	11	25	30	11.3	5.7	9712	271.3
16	13	25	30	11.2	5.2	9957	304.8
17	10	20	25	11.2	5.6	9597.5	273.3
18	14	20	25	11.2	5.1	9947	310.5
19	12	10	25	11.2	5.2	9723	301.9
20	12	30	25	11.2	5.3	9957	299.2
21	12	20	15	11.2	5.4	9764	282
22	12	20	35	11.2	5.3	9908	297.7
23	12	20	25	11	5.1	9880	314
24	12	20	25	11.5	5.7	9761	272.65
25	12	20	25	11.2	5.2	9859	301.9

DETAILS

Fusion zone size or nugget diameter is one of the most important factor that develops the mechanical properties of weld portion. The size of nugget is determined by heat input and rate heat input

Followings are the some observations made by using rsm curves.

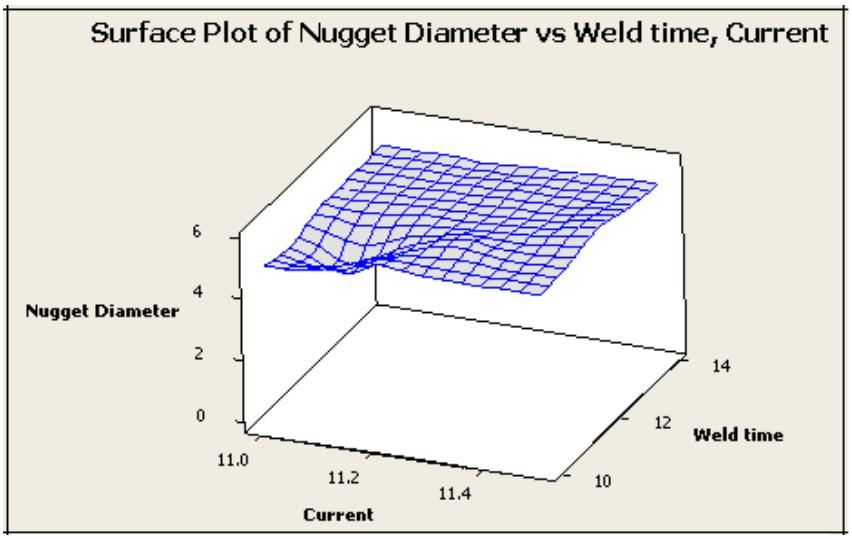

Figure 3: Effect of Current and Weld Time on Nugget Diameter Formation

Figure 3, shows estimated response surface for nugget diameter formation by using resistance spot welding with varying values of current and weld time .It can be seen that there were linear proportion between nugget diameter formation and weld time &current after some peak values.

Remaining part of research work is to find out relation between welding input resources with second output parameter like strength (Tensile) of weld. To find out the strength, the specimen made from above input parameters were tested on Universal testing machine and observed the failure mechanism. Generally spot weld fails in two modes interfacial and pull out. In interfacial mode failure occurs via crack propagation through fusion zone, while in pull out mode failure occurs via complete nugget withdrawals from one sheet[3].Interfacial failure requires maximum amount of load and maximum amount of energy due to less amount of plastic deformation during welding as compared to pull out mode.

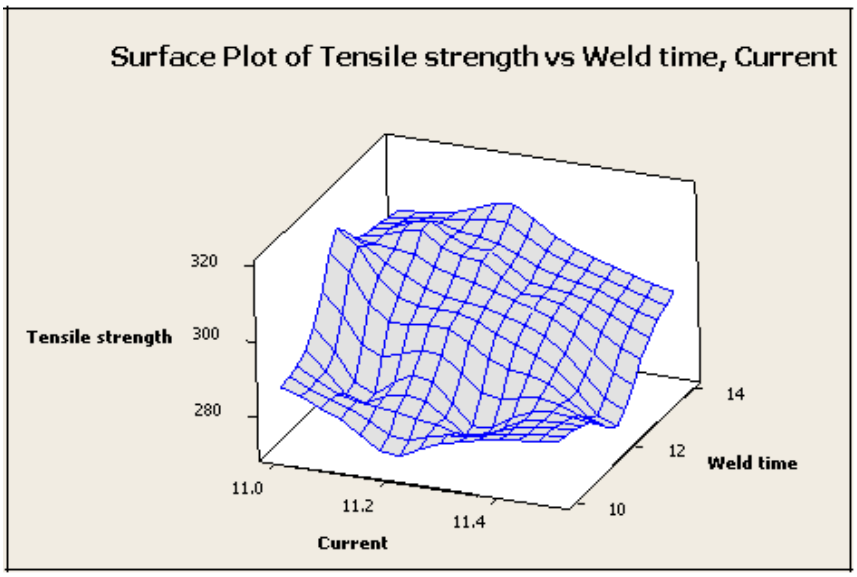

Figure 4: Effect of Current and Weld Time on Tensile Strength

Figure 4 shows estimated response surface for tensile strength of weld by using resistance spot welding with varying values of current & weld cycle. It can be seen that value of strength increase firstly with decreased peak value value of weld time after that if the value of weld time increases the value of strength remains constant. There is same relation for weld current and tensile strength.

Interfacial Failure **Pull Out Failure**

Figure 5: Failure Mode of Spot Welded Specimen

CONCLUSIONS

By analyzing the results from above experiments work can be concluded as follows:

The responses like Nugget Diameter and Tensile Strength of welded specimen are co related with each other. For moderate require ment of both responses we requires moderate value of input parameters from design of experiment tables.

The value of input parameter like current also determines the nature of failure mode for getting strength.

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